a

Printed by HPS Server
for

Walk-Up_Printing

Printer: cm1_11e14_gbegptr
Date: 07/15/03
Time: 11:57:49

Document Listing

Document	Selected Pages	Page Range	Copies
US004956477	19	1 - 19	1
US005547836	22	1 - 22	1
US005631167	18	1 - 18	1
Total (3)	59	-	-

XO 7/15

INTERLIBRARY LOAN FORM

485172

Examiner: Ralph Gitomer
Telephone Number: 308-0732
Serial Number: 09/883,586
Art Unit: 1651
Date Requested: 7/15/03
Date Needed: sometime
Please attach copy of abstract, citation or bibliography, if available
ONLY ONE REQUEST PER FORM

Schaap A. Paul
Chemical and Enzymatic Triggering...
Office of Naval Research NR 051-840
Technical Report #3, 3/1987

PTO Call No. ________ Accession Number ________

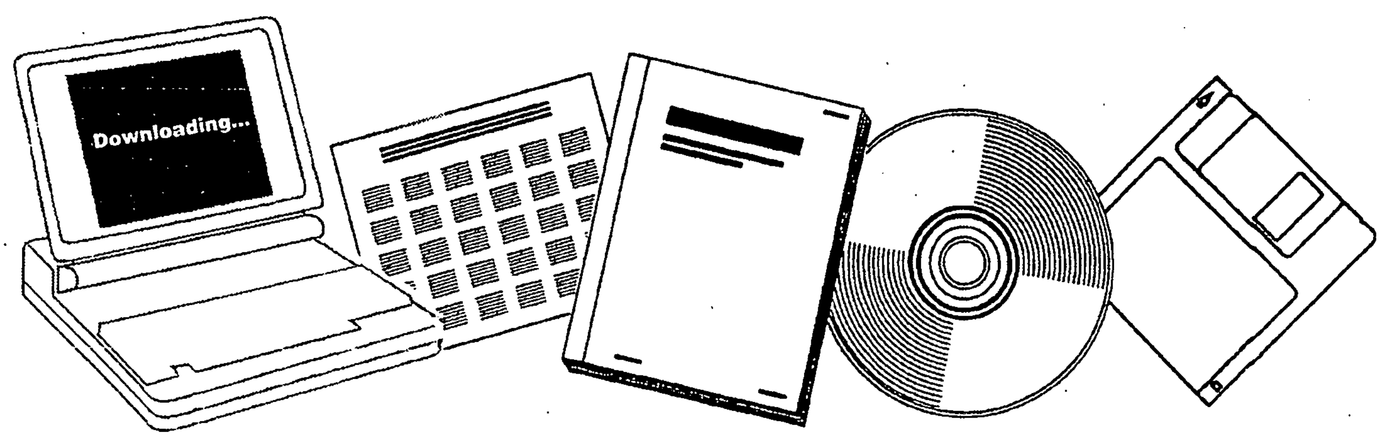
SCIENTIFIC LIBRARY USE ONLY

LIBRARY ACTION	LC	NAL	NIH	NLM	NBS	PTO	OTHER
DATE	7/16						~~NTIS~~ 7/17
INITIALS							NTIS
RESULTS	1403						
EXAMINER CALLED							
PAGE COUNT							
MONEY SPENT							

CHEMICAL AND ENZYMATIC TRIGGERING OF 1,2-DIOXETANES. 2. FLUORIDE-INDUCED CHEMILUMINESCENCE FROM TERT-BUTYLDIMETHYLSILYLOXY-SUBSTITUTED DIOXETANES

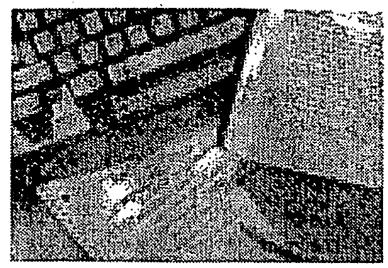
WAYNE STATE UNIV., DETROIT, MI. DEPT. OF CHEMISTRY

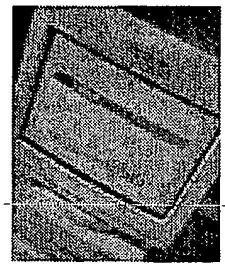
17 MAR 1987

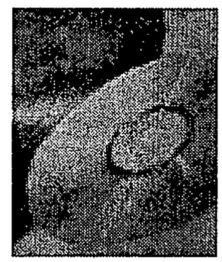


On S urce. On Search. One S luti n.

NTIS







Providing Permanent, Easy Access to U.S. Government Information

National Technical Information Service is the nation's largest repository and disseminator of government-initiated scientific, technical, engineering, and related business information. The NTIS collection includes almost 3,000,000 information products in a variety of formats: electronic download, online access, CD-ROM, magnetic tape, diskette, multimedia, microfiche and paper.

Search the NTIS Database from 1990 forward

NTIS has upgraded its bibliographic database system and has made all entries since 1990 searchable on **www.ntis.gov.** You now have access to information on more than 600,000 government research information products from this web site.

Link to Full Text Documents at Government Web Sites

Because many Government agencies have their most recent reports available on their own web site, we have added links directly to these reports. When available, you will see a link on the right side of the bibliographic screen.

Download Publications (1997 - Present)

NTIS can now provides the full text of reports as downloadable PDF files. This means that when an agency stops maintaining a report on the web, NTIS will offer a downloadable version. There is a nominal fee for each download for most publications.

For more information visit our website:

www.ntis.gov

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161

OFFICE OF NAVAL RESEARCH

Contract N00014-82-K-0696

Task No. NR 051-840

TECHNICAL REPORT #3

CHEMICAL AND ENZYMATIC TRIGGERING OF 1,2-DIOXETANES 2: FLUORIDE-INDUCED CHEMILUMINESCENCE FROM *TERT*-BUTYLDIMETHYLSILYLOXY-SUBSTITUTED DIOXETANES

by

A. Paul Schaap, Tsae-Shyan Chen, Richard Handley, Renuka DeSilva, and B. P. Giri

Prepared for Publication

in

Tetrahedron Letters

Department of Chemistry
Wayne State University
Detroit, MI 48202

March 17, 1987

CHEMICAL AND ENZYMATIC TRIGGERING OF 1,2-DIOXETANES. 2: FLUORIDE-INDUCED CHEMILUMINESCENCE FROM *TERT*-BUTYLDIMETHYLSILYLOXY-SUBSTITUTED DIOXETANES

A. Paul Schaap, Tsae-Shyan Chen, Richard S. Handley, Renuka DeSilva, and Brij P. Giri*
Department of Chemistry, Wayne State University, Detroit, MI 48202

Abstract: Thermally stable 1,2-dioxetanes bearing *tert*-butyldimethylsilyloxyaryl groups have been prepared. Reaction of these dioxetanes with fluoride ion at ambient temperature in MeCN and DMSO generates chemiluminescence with efficiencies up to 25%.

In 1982 we demonstrated that chemiluminescence from a 1,2-dioxetane bearing a phenolic substituent could be triggered by the addition of base.[1] Deprotonation generates an unstable phenoxide-substituted dioxetane which decomposes 4.4 x 10^6 times faster than the protonated form. We have now used this initial observation to develop other methods for triggering the chemiluminescent decomposition of thermally stable dioxetanes. For example, we have recently shown that a naphthyl acetate-substituted dioxetane can be *enzymatically* cleaved in aqueous buffers using aryl esterase.[2] We now provide the first example of chemical triggering of silyloxy-substituted dioxetanes by fluoride in DMSO or MeCN to generate chemiluminescence with efficiencies up to 25%.

Dioxetanes **2a-c** were prepared by photooxygenation of the corresponding alkenes[3] in CH_2Cl_2 using polymer-bound Rose Bengal[4] (SENSITOX I) and a 1000-W high-pressure sodium lamp. After 15 - 30 min irradiation the sensitizer was removed by filtration and the solvent evaporated under vacuum. Recrystallization of the material from pentane or chromatography over silica gave the dioxetanes.[5] Rate constants for the thermal decomposition of **2a-c** were obtained at 80 to 120 °C from measurements of the decay of chemiluminescence intensity of 10^{-4} M solutions in *o*-xylene.[6] Chemiluminescence spectra from 2a-c all exhibited a maximum at 437 nm indicating that the luminescence is derived from singlet excited adamantanone and not the phenyl or naphthyl esters. Rates showed variations of less than 3% and gave excellent Arrhenius plots (r > 0.99) with activation energies for **2a-c** of 29.7, 27.0, and 28.4 (± 1) kcal/mol, respectively (Table 1). Half-lives for 2a-c at 25 °C are calculated to be several years.[7] These results demonstrate the high degree of stabilization that can be obtained with sterically hindered adamantyl-substituted dioxetanes.[8]

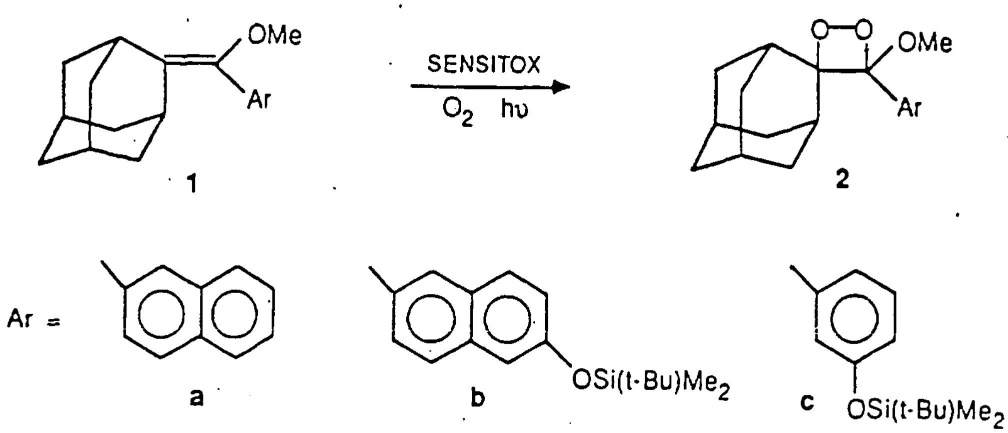


Table 1. Activation Parameters and Rates of Decomposition for 1,2-Dioxetanes 2a-c in o-Xylene.

dioxetane	E_a(kcal/mol)	log A	k(sec^{-1}) at 25 °C	half-life at 25 °C[a]
2a	29.7	13.2	3.17×10^{-9}	6.9 years
2b	27.0	11.7	8.72×10^{-9}	2.5 years
2c	28.4	12.6	5.74×10^{-9}	3.8 years

(a) Calculated from the Arrhenius plots.

Deprotection of silyl ethers with fluoride is a widely used reaction in modern organic synthesis.[9] We have now used this procedure to generate the unstable, chemiluminescent aryloxide dioxetanes **3b** and **3c** from the thermally stable forms **2b** and **2c**, respectively. In a typical experiment injecting an aliquot of an o-xylene solution of dioxetane **2b** into 3 mL of 0.001 M n-Bu_4NF in MeCN to give a final dioxetane concentration of 10^{-5} M produced a flash of blue chemiluminescence which decayed by a pseudo-first-order process with a half-life of less than 1 sec at room temperature. The spectrum of the resulting chemiluminescence exhibited a maximum at 470 nm which was identical to the fluorescence of **4b**[10] and the fluorescence of the spent dioxetane solution under these conditions. No chemiluminescence derived from adamantanone fluorescence appears to be produced. Analysis of the crude product mixture resulting from treatment of a sample of **2b** with 1 equivalent of n-Bu_4NF by ^1H NMR and UV revealed only the expected cleavage products: adamantanone and the tetra-n-butylammonium salt of methyl 6-hydroxy-2-naphthoate in a 1:1 ratio.

The chemiluminescence quantum yield for the fluoride-triggered decomposition of dioxetane **2b** was measured relative to the luminol standard[11] using a photon-counting apparatus.[12] Fluoride-triggered decomposition of 10^{-5} M solutions of **2b** in MeCN at 25 °C produced chemiluminescence with a quantum yield of 4×10^{-5} which was independent of fluoride concentration in the range 10^{-2} to 10^{-4} M. Correction for the fluorescence quantum yield of **4b** in MeCN under identical conditions leads to a calculated chemiexcitation quantum yield of 1.1×10^{-4} or an efficiency for the formation of singlet excited **4b** of 0.01% (Table 2).[13]

In contrast to the low chemiluminescence quantum yield on triggering the decomposition of **2b**, we find that treatment of **2c** with fluoride produces chemiluminescence with dramatically higher efficiency. Addition of excess n-Bu_4NF to 10^{-7} M solutions of dioxetane **2c** in MeCN resulted in a rapid decomposition of **2c** accompanied by bright blue chemiluminescence with a half-life of 5 sec at 25 °C. The pseudo-first-order rate constant was independent of fluoride concentration in the range 6.7×10^{-5} to 3.3×10^{-3} M. The spectrum of the resulting chemiluminescence exhibited a maximum at 470 nm in MeCN which matched exactly the fluorescence of **4c** under these conditions. Similar experiments were conducted in DMSO (Figure 1).[14] Quantum yields for the chemiluminescence of **2c** with

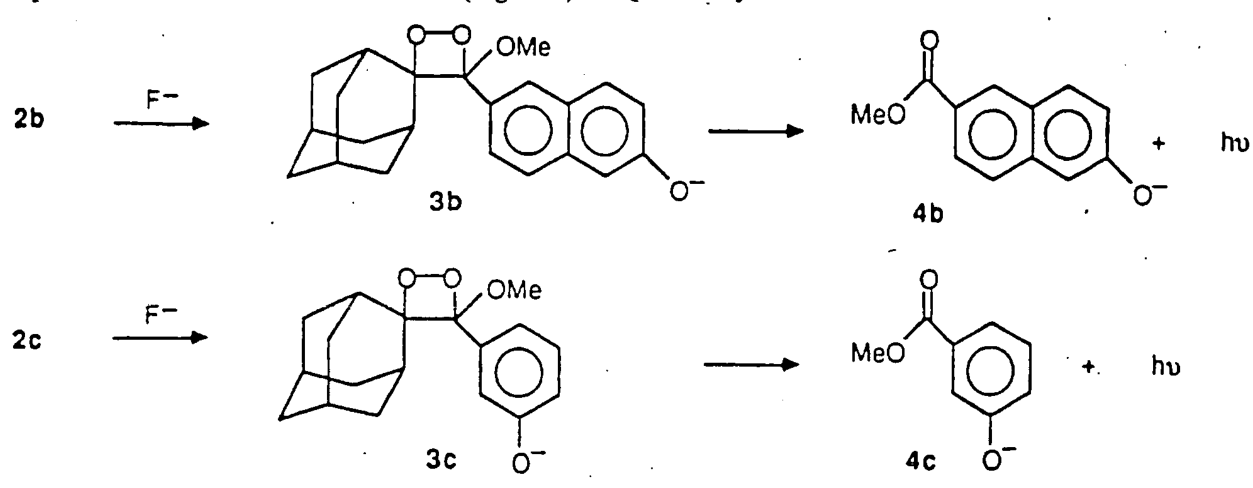


Table 2. Fluoride-Induced Chemiluminescence from Dioxetanes 2b and 2c.

dioxetane	solvent	Φ_{CL}^{a}	Φ_{F}^{b}	Φ_{CE}^{c}
2b	MeCN	4×10^{-5}	0.37	1.1×10^{-4}
2c	MeCN	0.094	0.21	0.45
2c	DMSO	0.25	0.44	0.57

(a). Chemiluminescence quantum yields. (b). Fluorescence quantum yields for cleavage products 4b and 4c relative to quinine sulfate with a value of 0.54. (c). Quantum yields for the formation of the singlet excited state of 4b and 4c.

fluoride were determined in MeCN and DMSO[15] relative to the luminol standard and found to be 0.094 and 0.25, respectively (Table 2). Correction for the fluorescence quantum yields of **4c** in these solvents gives efficiencies for the formation of singlet excited **4c** of 45 and 57%, one of the highest singlet chemiexcitation efficiencies yet reported for a dioxetane.[16]

These results are readily explained by a mechanism initiated by cleavage of the Si-O bond by fluoride to generate the unstable dioxetanes **3b** and **3c**. The lack of any dependence of the rate of decay of the chemiluminescence on fluoride concentration suggests that the rate-limiting step under these conditions may be the cleavage of the aryloxide dioxetanes **3b** and **3c**.[17] The rapid decomposition of these intermediates is induced by an intramolecular electron transfer from the strongly electron-donating phenoxide type substituent to the peroxide σ* orbital.[1] Similiar mechanisms have been proposed for the efficient chemiluminescence from dioxetanes bearing easily oxidized substituents.[18] Chemiluminescence has also been observed from intermolecular electron-transfer reactions between peroxides and fluorescent hydrocarbons.[19] The reason for the significant difference in the chemiexcitation efficiencies of **3b** and **3c** is currently under investigation. We have prepared the corresponding *p-tert*-butyldimethylsilyloxyphenyl-substituted dioxetane and found the chemiexcitation efficiency to also be less than 0.01% in that case.

We are continuing our work with dioxetane **2c** and related derivatives with a view towards the possible use of this system as a convenient liquid light standard. Solutions of **2c** prepared in *o*-xylene exhibit high stability and can be stored for long periods. A stock solution of **2c** kept at room temperature gave identical results after one month. Typically, the calibration of a luminometer can be carried out by injecting 30 μL of a 10^{-5} M solution of **2c** into 3 mL of a 0.003 M solution of $n\text{-}Bu_4NF$ in dry DMSO. The luminescence is emitted over a 20 sec period with 1-2% reproduciblity for the total light emission.

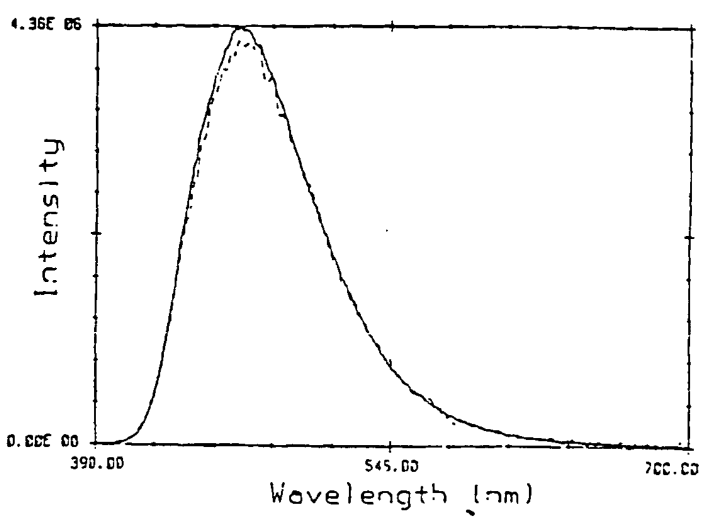


Figure 1. Chemiluminescence spectrum from fluoride triggering of dioxetane 2c in DMSO (----). Fluorescence spectrum of 4c under the same conditions (——).

Acknowledgments. Support of this research by the Office of Naval Research is gratefully acknowledged. We also wish to thank Mr. Marc Budrick for his assistance with the synthesis of the alkenes.

References and Notes

1. Schaap, A. P.; Gagnon, S. D. *J. Am. Chem. Soc.* 1982, *104*, 3504.
2. Schaap, A. P.; Handley, R. S.; Giri, B. P. *J. Am. Chem. Soc.*, submitted for publication.
3. The preparation of the alkenes will be described in a subsequent paper.
4. Schaap, A. P., Thayer, A. L., Blossey, E. C., Neckers, D. C. *J. Am. Chem. Soc.* 1975, *97*, 3741.
5. 4-Methoxy-4-(2-naphthyl)spiro[1,2-dioxetane-3,2'-adamantane] (**2a**): mp 116 ^{o}C (dec); ^{1}H NMR δ 0.9-2.0 (m, 12H), 2.22 (s, 1H), 3.11 (s, 1H), 3.24 (s, 3H), 7.0-8.3 (m, 7H); ^{13}C NMR δ 25.94, 26.07, 31.60, 31.72, 32.31, 33.08, 33.23, 34.88, 36.42, 50.00, 95.60, 112.33, 125.21, 126.47, 127.02, 127.63, 127.91, 128.67, 129.41, 132.13, 132.85, 133.61. 4-(6-*tert*-Butyldimethylsilyloxy-2-naphthyl)-4-methoxyspiro[1,2-dioxetane-3,2'-adamantane] (**2b**): mp 107 ^{o}C (dec); ^{1}H NMR δ 0.27 (s, 6H), 1.03 (s, 9H), 1.4-2.0 (m, 12H), 2.2 (s, 1H), 3.1 (s, 1H), 3.23 (s, 3H), 7.1-7.85 (m, 6H); ^{13}C NMR δ -4.33, 18.23, 25.67, 25.93, 26.06, 31.59, 31.69, 32.31, 33.04, 33.19, 34.86, 36.42, 49.94, 95.59, 112.44, 114.63, 122.58, 126.64, 128.50, 129.85, 130.11, 134.93, 154.59. 4-(3-*tert*-Butyldimethylsilyloxyphenyl)-4-methoxyspiro[1,2-dioxetane-3,2'-adamantane](**2c**): oil, ^{1}H NMR δ 0.20 (s, 6H), 0.99 (s, 9H), 1.26-1.90 (m, 13H), 3.02 (s, 1H), 3.23 (s, 3H), 6.86-7.30 (m, 4H); ^{13}C NMR δ -4.34, 18.33, 25.77, 26.18, 26.07, 31.62, 31.70, 32.50, 33.00, 33.26, 34.80, 36.56, 49.94, 95.30, 111.91, 119.32, 121.26, 123.90, 129.18, 136.10, 155.86.
6. NMR experiments have shown that **2b-c** undergo thermal decomposition to give 2-adamantanone and the expected silyloxyaryl ester.
7. Actual half-lives could be shorter if the solvents used for storage of the dioxetanes contained impurities which could lead to catalytic decomposition. Experiments are in progress to provide a direct measure of the stability of these dioxetanes at ambient temperature.
8. For other adamantyl-substituted dioxetanes, see (a) Wieringa, J. H.; Strating, J.; Wynberg, H.; Adam, W. *Tetrahedron Lett.* 1972, 169. (b) Turro, N. J.; Schuster, G.; Steinmetzer, H. -C.; Faler, G. R.; Schaap, A. P. *J. Am. Chem. Soc.* 1975, *97*, 7110. (c) McCapra, F.; Behesti, I.; Burford, A.; Hann, R. A.; Zaklika, K. A. *J. Chem. Soc., Chem. Commun.* 1977, 944. (d) Adam, W.; Encarnacion, L. A. A.; Zinner, K. *Chem. Ber.* 1983, *116*, 839.
9. Corey, E. J.; Venkateswarlu, A. *J. Am. Chem. Soc.* 1972, *94*, 6190. For additional references to the deprotection of alcohols with fluoride, see: Greene, T. W. in "Protective Groups in Organic Synthesis," Wiley, New York, 1981.
10. Solutions of **4b** and **4c** were produced by treating the silyloxy-protected esters with fluoride.
11. (a) Lee, J.; Seliger, H. H. *Photochem. Photobiol.* 1972, *15*, 227. (b) Michael, P. R.; Faulkner, L. R. *Anal. Chem.* 1976, *48*, 1188.
12. Quantum yields were determined using a luminometer constructed in our laboratory with an RCA A-31034A gallium-arsenide PMT cooled to - 78 °C and Ortec photon-counting electronics.
13. For a discussion of the calculation of chemiluminescence quantum yields, see: Wilson, T. *Int. Rev. Sci.: Phys. Chem., Ser. Two 1976*, *9*, 265.
14. Chemiluminescence spectra were acquired with a Spex Fluorolog spectrofluorometer. Correction for the decay of the chemiluminescence intensity during the wavelength scan was made by accumulating the spectrum in a ratio mode using an auxiliary detector to measure the total signal as a function of time.
15. Spectral grade MeCN was obtained from Burdick and Jackson Laboratories, Inc. Reagent grade DMSO from several sources gave identical quantum yields. We have used the trihydrate of n-Bu_4NF for these experiments. Other sources of fluoride produced similar results. We have noted that direct addition of fluoride to "old" samples of these solvents produces a very weak chemiluminescence in the absence of the dioxetanes.
16. For a listing of chemiexcitation efficiencies, see: Adam, W. in "Chemical and Biological Generation of Excited States," Eds. Adam, W.; Cilento, G., Academic Press, New York, 1982, Chapter 4.
17. It should be noted, however, that use of solvents containing appreciable amounts of water with resulting lower reactivity of fluoride leads to reaction rates that show a dependence on fluoride concentration.
18. (a) McCapra, F.; Beheshti, I.; Burford, A.; Hann, R. A.; Zaklika, K. A. *J. Chem. Soc., Chem. Commun.* 1977, 944. (b) Zaklika, K. A.; Thayer, A. L.; Schaap, A. P. *J. Am. Chem. Soc.* 1978, *100*, 4916. (c) Zaklika, K. A.; Kissel, T.; Thayer, A. L.; Burns, P. A.; Schaap, A. P. *Photochem. Photobiol.* 1979, *30*, 35. (d) Nakamura, H.; Goto, T. *Ibid.* 1979, *30*, 29. (e) Lee, C.; Singer, L. A. *J. Am. Chem. Soc.* 1980, *102*, 3832. (f) Schaap, A. P.; Gagnon, S. D.; Zaklika, K. A. *Tetrahedron Lett.* 1982, 2943.
19. (a) Schuster, G. B.; Schmidt, S. P. *Adv. Phys. Org. Chem.* 1982, *18*, 187. (b) Adam, W.; Cueto, O. J. *J. Am. Chem. Soc.* 1979, *101*, 6511.

DL/1113/86/2

TECHNICAL REPORT DISTRIBUTION LIST, GEN

	No. Copies
Office of Naval Research Attn: Code 1113 800 N. Quincy Street Arlington, Virginia 22217-5000	2
Dr. Bernard Douda Naval Weapons Support Center Code 50C Crane, Indiana 47522-5050	1
Naval Civil Engineering Laboratory Attn: Dr. R. W. Drisko, Code L52 Port Hueneme, California 93401	1
Defense Technical Information Center Building 5, Cameron Station Alexandria, Virginia 22314	12 high quality
DTNSRDC Attn: Dr. H. Singerman Applied Chemistry Division Annapolis, Maryland 21401	1
Dr. William Tolles Superintendent Chemistry Division, Code 6100 Naval Research Laboratory Washington, D.C. 20375-5000	1
Dr. David Young Code 334 NORDA NSTL, Mississippi 39529	1
Naval Weapons Center Attn: Dr. Ron Atkins Chemistry Division China Lake, California 93555	1
Scientific Advisor Commandant of the Marine Corps Code RD-1 Washington, D.C. 20380	1
U.S. Army Research Office Attn: CRD-AA-IP P.O. Box 12211 Research Triangle Park, NC 27709	1
Mr. John Boyle Materials Branch Naval Ship Engineering Center Philadelphia, Pennsylvania 19112	1
Naval Ocean Systems Center Attn: Dr. S. Yamamoto Marine Sciences Division San Diego, California 91232	1

TECHNICAL REPORT DISTRIBUTION LIST, 051A

Dr. M. A. El-Sayed
Department of Chemistry
University of California
Los Angeles, California 90024

Dr. E. R. Bernstein
Department of Chemistry
Colorado State University
Fort Collins, Colorado 80521

Dr. J. R. MacDonald
Chemistry Division
Naval Research Laboratory
Code 6110
Washington, D.C. 20375-5000

Dr. G. B. Schuster
Chemistry Department
University of Illinois
Urbana, Illinois 61801

Dr. J.B. Halpern
Department of Chemistry
Howard University
Washington, D.C. 20059

Dr. M. S. Wrighton
Department of Chemistry
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dr. A. Paul Schaap
Department of Chemistry
Wayne State University
Detroit, Michigan 49207

Dr. W.E. Moerner
I.B.M. Corporation
Almaden Research Center
650 Harry Rd.
San Jose, California 95120-6099

~~Dr. A.B.P. Lever~~
~~Department of Chemistry~~
~~York University~~
~~Downsview, Ontario~~
~~CANADA M3J1P3~~

Dr. John Cooper
Code 6173
Naval Research Laboratory
Washington, D.C. 20375-5000

Dr. George E. Walrafen
Department of Chemistry
Howard University
Washington, D.C. 20059

Dr. Joe Brandelik
AFWAL/AADO-1
Wright Patterson AFB
Fairborn, Ohio 45433

Dr. Carmen Ortiz
Consejo Superior de
Investigaciones Cientificas
Serrano 121
Madrid 6, SPAIN

Dr. John J. Wright
Physics Department
University of New Hampshire
Durham, New Hampshire 03824

Dr. Kent R. Wilson
Chemistry Department
University of California
La Jolla, California 92093

Dr. G. A. Crosby
Chemistry Department
Washington State University
Pullman, Washington 99164

Dr. Theodore Pavlopoulos
NOSC
Code 521
San Diego, California 91232

ABSTRACTS DISTRIBUTION LIST, 359/627

Dr. Paul Delahay
Department of Chemistry
New York University
New York, New York 10003

Dr. J. Driscoll
Lockheed Palo Alto Research Laboratory
3251 Hanover Street
Palo Alto, California 94304

Dr. D. N. Bennion
Department of Chemical Engineering
Brigham Young University
Provo, Utah 84602

Dr. R. A. Marcus
Department of Chemistry
California Institute of Technology
Pasadena, California 91125

Dr. J. J. Auborn
Bell Laboratories
Murray Hill, New Jersey 07974

Dr. Joseph Singer, Code 302-1
NASA-Lewis
21000 Brookpark Road
Cleveland, Ohio 44135

Dr. P. P. Schmidt
Department of Chemistry
Oakland University
Rochester, Michigan 48063

Dr. Roger Belt
Litton Industries Inc.
Airtron Division
Morris Plains, NJ 07950

Dr. Ulrich Stimming
Department of Chemical Engineering
Columbia University
New York, NY 10027

Dr. Manfred Breiter
Institut fur Technische Elektrochemie
Technischen Universitat Wien
9 Getreidemarkt, 1160 Wien
AUSTRIA

Dr. E. Yeager
Department of Chemistry
Case Western Reserve University
Cleveland, Ohio 44106

Dr. C. E. Mueller
The Electrochemistry Branch
Naval Surface Weapons Center
White Oak Laboratory
Silver Spring, Maryland 20910

Dr. Sam Perone
Chemistry & Materials Science Department
Lawrence Livermore National Laboratory
Livermore, California 94550

Dr. Royce W. Murray
Department of Chemistry
University of North Carolina
Chapel Hill, North Carolina 27514

Dr. Adam Heller
Bell Laboratories
Murray Hill, New Jersey 07974

Dr. A. B. Ellis
Chemistry Department
University of Wisconsin
Madison, Wisconsin 53706

Dr. Steven Greenbaum
Department of Physics and Astronomy
Hunter College
695 Park Ave.
New York, NY 10021

ABSTRACTS DISTRIBUTION LIST, 359/627

Dr. M. Wrighton
Chemistry Department
Massachusetts Institute
of Technology
Cambridge, Massachusetts 02139

Dr. B. Stanley Pons
Department of Chemistry
University of Utah
Salt Lake City, Utah 84112

Donald E. Mains
Naval Weapons Support Center
Electrochemical Power Sources Division
Crane, Indiana 47522

S. Ruby
DOE (STOR)
Room 5E036 Forrestal Bldg., CE-14
Washington, D.C. 20595

Dr. A. J. Bard
Department of Chemistry
University of Texas
Austin, Texas 78712

Dr. Janet Osteryoung
Department of Chemistry
State University of New York
Buffalo, New York 14214

Dr. Donald W. Ernst
Naval Surface Weapons Center
Code R-33
White Oak Laboratory
Silver Spring, Maryland 20910

Mr. James R. Moden
Naval Underwater Systems Center
Code 3632
Newport, Rhode Island 02840

Dr. Bernard Spielvogel
U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709

Dr. Aaron Fletcher
Naval Weapons Center
Code 3852
China Lake, California 93555

Dr. Michael J. Weaver
Department of Chemistry
Purdue University
West Lafayette, Indiana 47907

Dr. R. David Rauh
EIC Laboratories, Inc.
Norwood, Massachusetts 02062

Dr. Aaron Wold
Department of Chemistry
Brown University
Providence, Rhode Island 02192

Dr. Martin Fleischmann
Department of Chemistry
University of Southampton
Southampton SO9 5NH UNITED KINGDOM

Dr. R. A. Osteryoung
Department of Chemistry
State University of New York
Buffalo, New York 14214

Dr. John Wilkes
Air Force Office of Scientific
Research
Bolling AFB
Washington, D.C. 20332

Dr. D. Rolison
Naval Research Laboratory
Code 6171
Washington, D.C. 20375-5000

Dr. D. F. Shriver
Department of Chemistry
Northwestern University
Evanston, Illinois 60201

Dr. Edward M. Eyring
Department of Chemistry
University of Utah
Salt Lake City, UT 84112

Dr. M. M. Nicholson
Electronics Research Center
Rockwell International
3370 Miraloma Avenue
Anaheim, California

ABSTRACTS DISTRIBUTION LIST, 359/627

Dr. Hector D. Abruna
Department of Chemistry
Cornell University
Ithaca, New York 14853

Dr. A. B. P. Lever
Chemistry Department
York University
Downsview, Ontario M3J1P3

Dr. Stanislaw Szpak
Naval Ocean Systems Center
Code 633, Bayside
San Diego, California 95152

Dr. Gregory Farrington
Department of Materials Science
and Engineering
University of Pennsylvania
Philadelphia, Pennsylvania 19104

M. L. Robertson
Manager, Electrochemical
and Power Sources Division
Naval Weapons Support Center
Crane, Indiana 47522

Dr. T. Marks
Department of Chemistry
Northwestern University
Evanston, Illinois 60201

Dr. Micha Tomkiewicz
Department of Physics
Brooklyn College
Brooklyn, New York 11210

Dr. Lesser Blum
Department of Physics
University of Puerto Rico
Rio Piedras, Puerto Rico 00931

Dr. Joseph Gordon, II
IBM Corporation
5600 Cottle Road
San Jose, California 95193

Dr. Nathan Lewis
Department of Chemistry
Stanford University
Stanford, California 94305

Dr. D. H. Whitmore
Department of Materials Science
Northwestern University
Evanston, Illinois 60201

Dr. Alan Bewick
Department of Chemistry
The University of Southampton
Southampton, SO9 5NH UNITED KINGDOM

Dr. E. Anderson
NAVSEA-56Z33 NC #4
541 Jefferson Davis Highway
Arlington, VA

Dr. Bruce Dunn
Department of Engineering &
Applied Science
University of California
Los Angeles, California 90024

Dr. Elton Cairns
Energy & Environment Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

Dr. Richard Pollard
Department of Chemical Engineering
University of Houston
Houston, Texas 77004

Dr. M. Philpott
IBM Corporation
5600 Cottle Road
San Jose, California 95193

Dr. Donald Sandstrom
Boeing Aerospace Co.
P.O. Box 3999
Seattle, Washington 98124

Dr. Carl Kannewurf
Department of Electrical Engineering
and Computer Science
Northwestern University
Evanston, Illinois 60201

Dr. Joel Harris
Department of Chemistry
University of Utah
Salt Lake City, Utah 84112

ABSTRACTS DISTRIBUTION LIST, 359/627

Dr. Robert Somoano
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California 91103

Dr. Johann A. Joebstl
USA Mobility Equipment R&D Command
DRDME-EC
Fort Belvoir, Virginia 22060

Dr. Judith H. Ambrus
NASA Headquarters
M.S. RTS-6
Washington, D.C. 20546

Dr. Albert R. Landgrebe
U.S. Department of Energy
M.S. 6B025 Forrestal Building
Washington, D.C. 20595

Dr. J. J. Brophy
Department of Physics
University of Utah
Salt Lake City, Utah 84112

Dr. Charles Martin
Department of Chemistry
Texas A&M University
College Station, Texas 77843

Dr. H. Tachikawa
Department of Chemistry
Jackson State University
Jackson, Mississippi 39217

Dr. Farrell Lytle
Boeing Engineering and
Construction Engineers
P.O. Box 3707
Seattle, Washington 98124

Dr. Robert Gotscholl
U.S. Department of Energy
MS G-226
Washington, D.C. 20545

Dr. Edward Fletcher
Department of Mechanical Engineering
University of Minnesota
Minneapolis, Minnesota 55455

Dr. John Fontanella
Department of Physics
U.S. Naval Academy
Annapolis, Maryland 21402

Dr. Martha Greenblatt
Department of Chemistry
Rutgers University
New Brunswick, New Jersey 08903

Dr. John Wasson
Syntheco, Inc.
Rte 6 - Industrial Pike Road
Gastonia, North Carolina 28052

Dr. Walter Roth
Department of Physics
State University of New York
Albany, New York 12222

Dr. Anthony Sammells
Eltron Research Inc.
4260 Westbrook Drive, Suite 111
Aurora, Illinois 60505

Dr. C. A. Angell
Department of Chemistry
Purdue University
West Lafayette, Indiana 47907

Dr. Thomas Davis
Polymer Science and Standards
Division
National Bureau of Standards
Washington, D.C. 20234

ABSTRACTS DISTRIBUTION LIST, 359/627

Dr. John Owen
Department of Chemistry and
Applied Chemistry
University of Salford
Salford M5 4WT ENGLAND

Dr. Boone Owens
Department of Chemical Engineering
and Materials Science
University of Minnesota
Minneapolis, Minnesota 55455

Dr. Menahem Anderman
W.R. Grace & Co.
~~Columbia, MD 20144~~

Dr. J. O. Thomas
University of Uppsala
Institute of Chemistry
Box 531
S-751 21 Uppsala, Sweden

Dr. O. Stafsudd
Department of Electrical Engineering
University of California
Los Angeles, California 90024

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161 (703) 605-6000